JURONG JUNIOR COLLEGE
2014 JC2 Preliminary Examination

Name		Class	14S

PHYSICS **8866/02**
Higher 1
Structured Questions **03 Sept 2014**
2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your **name** and **class** in the spaces provided at the top of this page.

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **two** questions.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
Section B	
6	
7	
8	
Total	

(This question paper consists of 27 printed pages)

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}$ m s^{-1}
elementary charge,	e	$= 1.60 \times 10^{-19}$ C
the Planck constant,	h	$= 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	u	$= 1.66 \times 10^{-27}$ kg
rest mass of electron,	m_e	$= 9.11 \times 10^{-31}$ kg
rest mass of proton,	m_p	$= 1.67 \times 10^{-27}$ kg
acceleration of free fall,	g	$= 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	s	$= ut + \frac{1}{2}at^2$
	v^2	$= u^2 + 2as$
work done on/by a gas,	W	$= p\,\Delta V$
hydrostatic pressure,	p	$= \rho g h$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$

Section A

Answer **all** questions in this section.

1 A stuntman on a motorcycle plans to ride up a ramp in order to jump over a number of cars as shown in **Fig. 1**.

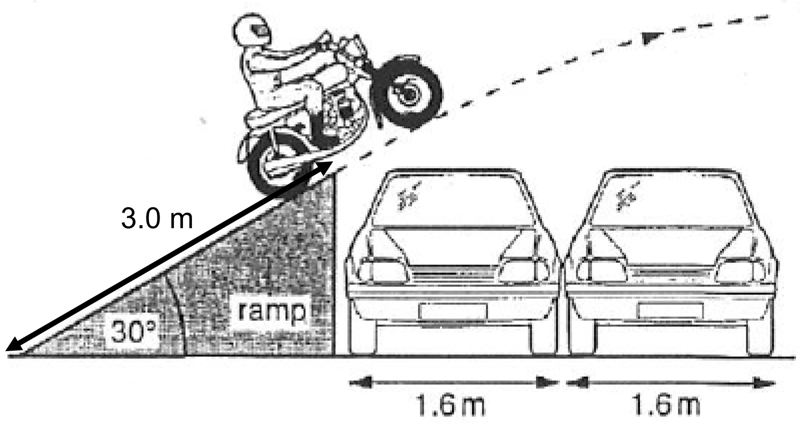

Fig. 1

He accelerates from rest from the bottom of the ramp and leaves it at a velocity of 9.0 m s^{-1}. The length of the ramp is 3.0 m. Assume that air resistance is negligible and he undergoes constant acceleration.

(a) **(i)** Determine his minimum acceleration in order for him to reach a take-off velocity of 9.0 m s^{-1} when he leaves the ramp.

acceleration = ______________________ m s^{-2} [2]

(ii) Suggest why the ramp cannot be frictionless in order for him to travel up the ramp.

....

....

....

.... [1]

(b) The cars are each of width 1.6 m and the same height as the ramp. Estimate the maximum number of cars which he can jump over.

maximum number of cars = ... [3]

2 **(a)** Power can be calculated from the equation

$$P = Fv$$

Derive this equation, starting from the definition of power.

[1]

(b) A cyclist pedaling along a horizontal road provides 200 W of useful power. The cyclist reaches a steady speed of 5.0 m s^{-1}.

Determine the value of the drag force against which the cyclist is working.

drag force = ... N [2]

(c) The drag force is proportional to the speed of the bicycle.

(i) Show that the useful power the cyclist must produce at speed v along the horizontal road is proportional to v^2.

[1]

(ii) Calculate the useful power the cyclist must produce to reach a steady speed 6.0 m s^{-1} along the horizontal road.

power = ... W [2]

(d) Calculate the useful power the cyclist would have to develop to maintain a speed of 5.0 m s^{-1}, when climbing a hill with a slope of angle 10^{o}.

Take the total mass of cyclist and bicycle to be 100 kg.

power = ... W [2]

3 **(a)** Define *magnetic flux density*.

[2]

(b) **(i)** **Fig. 3.1** shows the cross-section of a conductor which carries a constant current flowing out of the plane of the paper.

Sketch the magnetic field due to the current. [2]

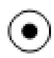

Fig. 3.1

(ii) The current-carrying conductor in **(b)(i)** is placed in the region between the poles of a strong magnet as shown in **Fig. 3.2**.

Sketch in **Fig. 3.2** the resultant magnetic field in the region between the poles of a magnet. [2]

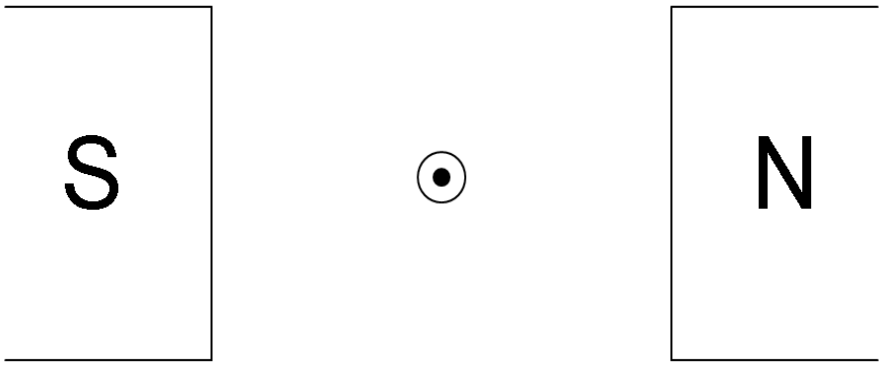

Fig. 3.2

(iii) State the direction of the magnetic force acting on the current-carrying conductor.

____ [1]

(iv) The magnetic flux density of the uniform field between the poles of the strong magnet is 0.50 T. The current in the conductor is 1.5 A and the length of the conductor that lies within the magnetic field is 0.10 m.

Calculate the magnetic force acting on the current-carrying conductor.

magnetic force = ________________ N [1]

4 **(a)** Calculate the energy of a photon of wavelength 480 nm from a hydrogen lamp.

energy = ... eV [2]

(b) **Fig. 4** is a graph showing the maximum kinetic energies of electrons emitted from a sodium surface by light of different frequencies from the hydrogen lamp.

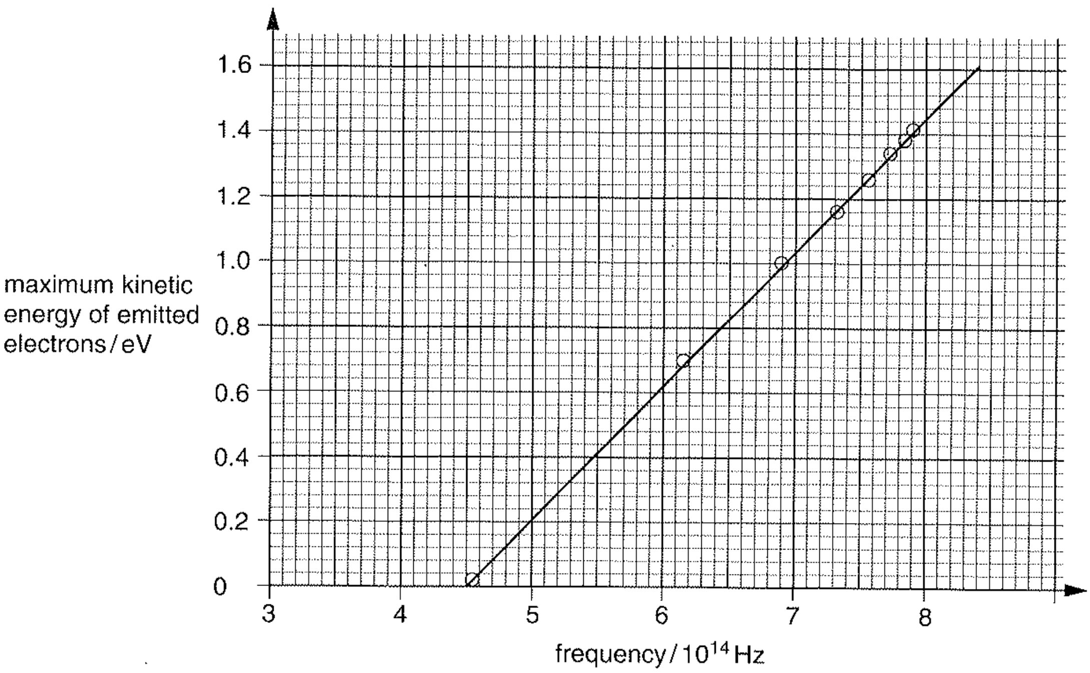

Fig. 4

(i) What is the threshold frequency for sodium?

threshold frequency = ... Hz [1]

(ii) When the photon in **(a)** is incident on the sodium surface, show that the value of the maximum kinetic energy of an emitted electron shown in **Fig. 4** is consistent with Einstein's photoelectric equation. [2]

(c) The frequencies of light from the hydrogen lamp in **(b)**, shown by the small circles on the graph in **Fig. 4**, are the only frequencies obtained in this range.

(i) Explain how this shows the existence of discrete energy levels in hydrogen atoms.

[2]

(ii) Without giving numerical values, sketch the possible energy level diagram of the hydrogen atom in **(i)**. [1]

5 In the model of the hydrogen atom developed by Neils Bohr in 1912, an electron of mass m and carrying charge $-e$ is moving at a constant speed v in a stable circular orbit radius r about a proton carrying $+e$, as indicated in **Fig. 5.1**. Here the approximation will be made that the proton is so much massive than the electron that it can be regarded as stationary.

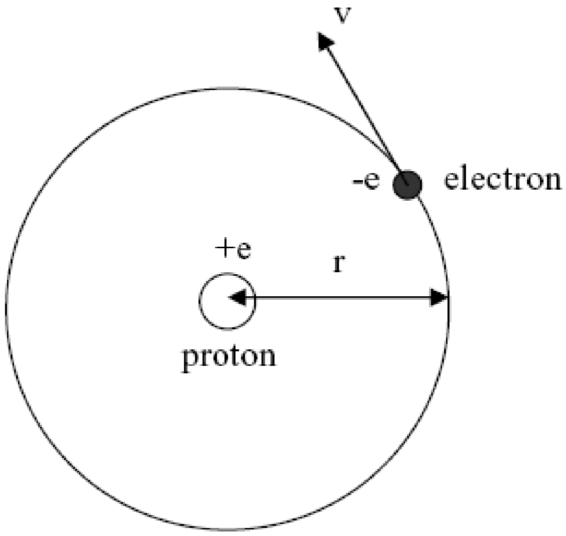

Fig. 5.1

Bohr predicted that the allowable energies of the hydrogen atom were quantized and were given by

$$E = -\frac{13.6}{n^2} \text{ eV}, \qquad \text{where } n = 1, 2, 3\ldots \qquad \textbf{Equation 1}$$

(a) **(i)** Using **Equation 1**, complete **Fig. 5.2** for the energy of the various states for the hydrogen atom according to the Bohr model. [2]

n	***E* / eV**
1	–13.60
2	
3	
4	–0.85
5	
6	
∞	0

Fig. 5.2

(ii) Use the data in **Fig. 5.2**, **draw to scale** on the graph paper an energy level diagram for the hydrogen atom in **Fig. 5.3**. Three of the energy levels have been drawn. [2]

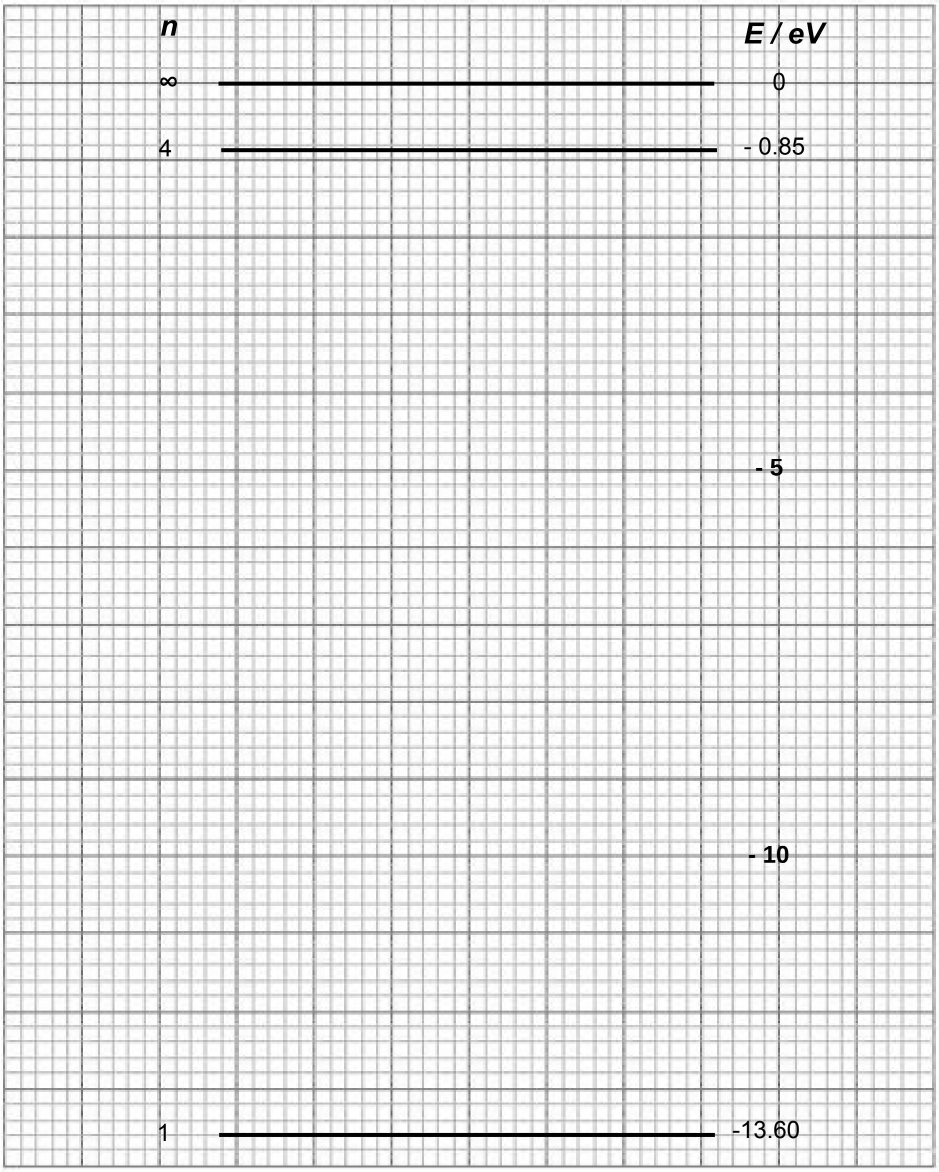

Fig. 5.3

(b) Before Bohr's theory of the hydrogen atom it had been found that the wavelength of the hydrogen spectrum could be arranged in a formula or series named after its discoverer. The ultraviolet spectrum was the Lyman series, the visible spectrum was the Balmer series, and the infrared spectrum was the Paschen series. The Lyman series, Balmer series and Paschen series are formed when excited electrons de-excite to n = 1, n = 2 and n = 3 states respectively.

(i) By considering only the states in **Fig. 5.2**, draw on **Fig. 5.3** all possible transitions between energy levels in a hydrogen atom for the *Balmer series.* [2]

(ii) Justify your answer by showing that one of the wavelengths in the series indeed lies in the visible region of the electromagnetic spectrum. [3]

(iii) Indicate clearly with symbol **R** in **Fig. 5.3**, the transition responsible for the red line observed in the spectrum. [1]

Section B

Answer **two** questions from this section.

6 **(a)** State the conditions for an object to be in equilibrium.

1. ....

....

2. ....

.... [2]

(b) A non-uniform bar of mass *m* is suspended at rest in a horizontal position by two cords of negligible mass which makes angles of 36.9° and 53.1° with the vertical as shown in **Fig. 6.1**. T_1 and T_2 are tensions in the cords.

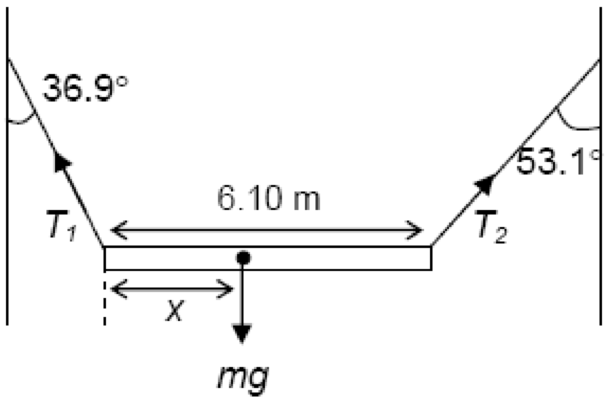

Fig. 6.1

The length of the bar is 6.10 m.

(i) Show that $T_1 = 1.33\ T_2$. [1]

(ii) Hence, or otherwise determine the distance *x*.

distance = ... m [2]

(c) A car and a truck are both travelling at the same high speed but in opposite directions as shown in **Fig. 6.2**. The truck has twice the mass of the car.

Fig. 6.2

The vehicles collide head-on and become entangled together.

(i) Which of the drivers is likely to suffer more serious injury in the collision? Explain.

[2]

(ii) Explain how the use of air-bags would help in the safety of the driver during collision.

[2]

(d) A simple two-stage rocket consists of component A of mass *2m* and component B of mass 3*m*. The rocket is travelling in space at a constant speed V_o when an internal explosion causes component B to move backwards with a speed of $\frac{1}{3}V_o$.

(i) Determine in terms of V_o, the speed of component A after the internal explosion.

speed = ... V_o [2]

(ii) Explain briefly why this two-stage rocket launching is advantageous compared to a single-stage launching from Earth.

[2]

(e) **Fig. 6.3** shows speed-time graphs for three spherical objects made of the same material but different radii, a_1, a_2, a_3, falling through the air after they are released from rest.

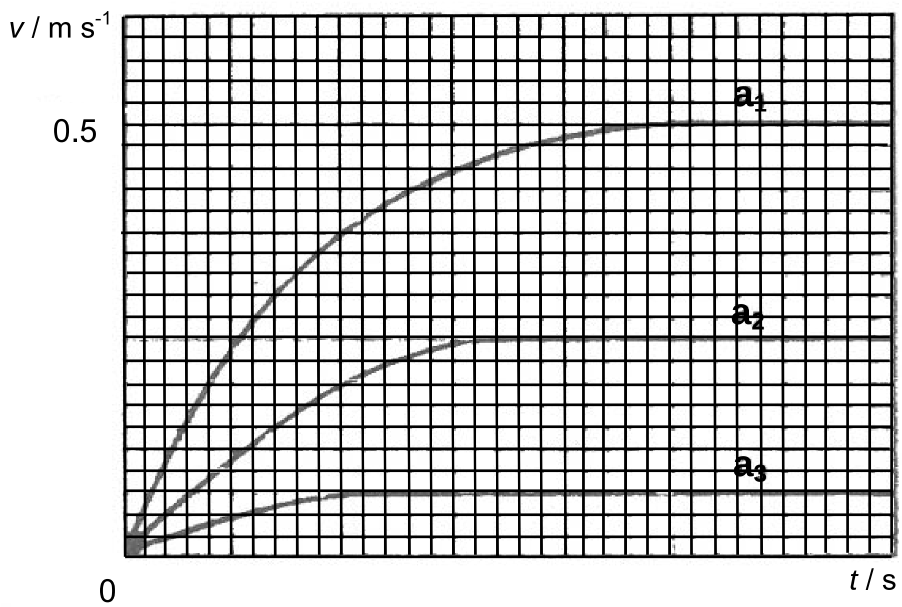

Fig. 6.3

(i) Explain qualitatively why the speeds tend to a constant value.

[3]

(ii) In terms of conservation of energy, explain how the final speed is maintained constant.

....

....

....

....

....

....

.... [2]

(iii) If the constant speed of a falling sphere is proportional to the square of its radius, calculate a_2 given that a_1 = 2.0 mm.

a_2 = ... mm [2]

7 **(a)** In terms of energy considerations, distinguish between the *electromotive force* of a cell and the *potential difference* between its terminals.

....

....

....

....

.... [2]

(b) **Fig. 7.1** shows how the resistance of a light-dependent resistor (LDR), a type of variable resistor, varies with the intensity of the light incident on it.

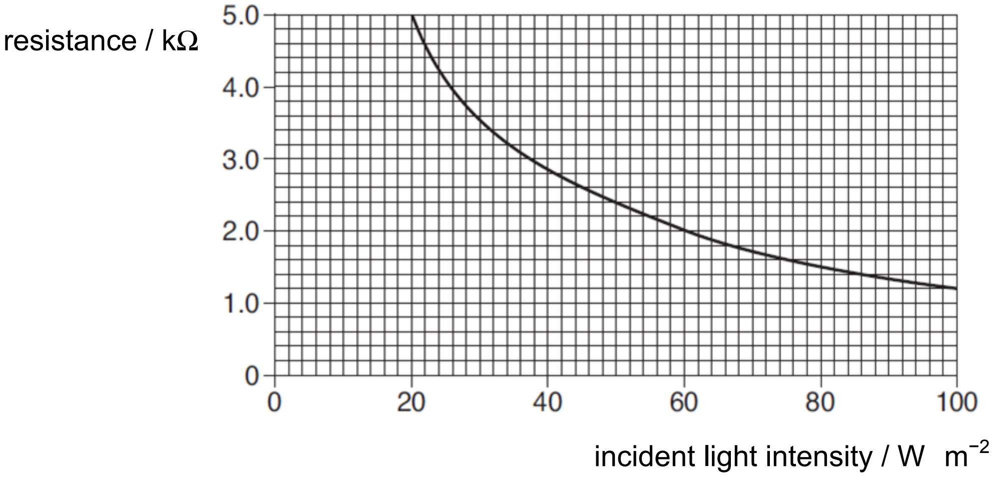

Fig. 7.1

Fig. 7.2 shows part of a light-sensing circuit used in a lamp where the potential difference across the LDR can be used to control the brightness of the lamp in a room.

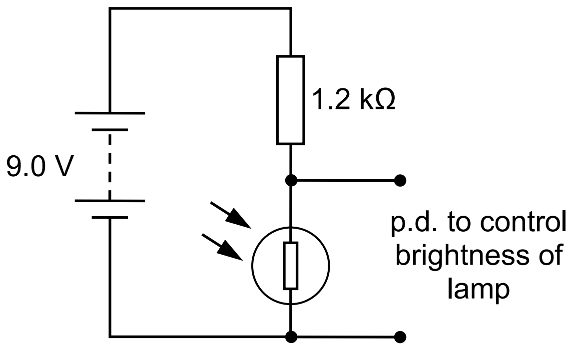

Fig. 7.2

The battery has an e.m.f. of 9.0 V and negligible internal resistance. The 1.2 kΩ resistor is made of carbon. When the room is in a low-light condition, the potential difference across the LDR reaches 7.0 V.

(i) State the potential difference across the 1.2 kΩ resistor, when the room is in the same low-light condition.

potential difference = ... V [1]

(ii) Hence, calculate the resistance *R* of the LDR.

resistance = ... kΩ [2]

(iii) Use **Fig. 7.1** to determine the light intensity when the p.d. across the LDR is 7.0 V.

intensity = ... W m^{-2} [1]

(iv) **Fig. 7.3** shows a magnified interior of the LDR device used in the circuit in **Fig. 7.2**. The LDR consists of a uniform strip of semiconductor - a material which has a resistivity, between that of a conductor and an insulator and is, dependent on the intensity of the light incident on it. The cross-sectional area of the strip is 5.0×10^{-7} m^2.

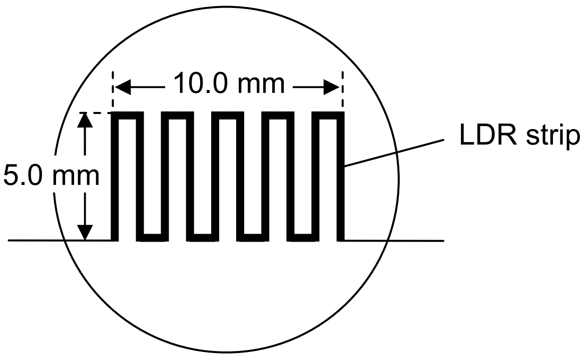

Fig. 7.3

Use your answer in **(ii)** to determine the resistivity of the LDR.

resistivity = ... Ω m [2]

(c) **Fig. 7.4** shows a circuit containing five identical lamps A, B, C, D and E. The circuit also contains three switches S_1, S_2 and S_3.

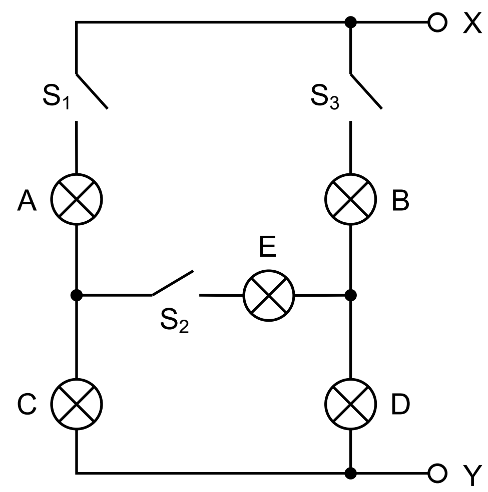

Fig. 7.4

One of the lamps is faulty. In order to detect the fault, an ohm-meter (a meter that measures resistance) is connected between terminals X and Y. When measuring resistance, the ohm-meter causes negligible current in the circuit.

Fig. 7.5 shows the readings of the ohm-meter for different switch positions.

The resistance of the non-faulty lamps can be assumed to be constant.

switch			metre reading
S_1	S_2	S_3	/ Ω
open	open	open	∞
closed	open	open	30.0
closed	closed	open	22.5
closed	closed	closed	15.0

Fig. 7.5

(i) Identify the faulty lamp, and the nature of the fault.

faulty lamp: ....

nature of fault: ....

.... [2]

(ii) Suggest why it is advisable to test the circuit using an ohm-meter that causes negligible current rather than with a power supply across terminals X and Y.

....

....

....

.... [1]

(iii) State the resistance of one of the non-faulty lamps, as measured using the ohm-meter.

resistance = ... Ω [1]

(iv) After replacing the faulty lamp in the circuit in **Fig. 7.4** with a similar working lamp, the ohm-meter is connected between terminals X and Y.

On **Fig. 7.6**, complete the readings of the ohm-meter for different switch positions.

switch S_1	switch S_2	switch S_3	metre reading / Ω
open	open	open	
closed	open	open	
closed	closed	open	
closed	closed	closed	

Fig. 7.6

[4]

(v) Each lamp is marked 12.0 V, 0.40 A.

Calculate, for one of the lamps operating at normal brightness,

1. its resistance

resistance = ... Ω [1]

2. its power dissipation

power dissipation = ... W [1]

(vi) Comment on your answers to **(iii)** and **(v)1**.

....

....

....

....

....

.... [2]

8 **(a)** Distinguish between *longitudinal* and *transverse* waves

[2]

(b) A certain wave has wavelength 1.00 m. What is the distance between two points on this wave with a phase difference of $\frac{\pi}{4}$ rad?

distance = ... m [2]

(c) A wave of amplitude *A* and intensity I is coincident with a second wave of amplitude 3*A*. Both waves have the same frequency. Calculate, in terms of I, the resultant intensity when the phase difference is π rad.

resultant intensity = ... I [2]

(d) To determine the wavelength of sound in air, the sound from a loudspeaker is directed normally towards a reflector. A microphone attached to a cathode-ray-oscilloscope (CRO) is moved along a line between the loudspeaker and the reflector.

(i) Describe briefly a simple procedure to determine the wavelength of sound in air.

[2]

(ii) Explain why the position of the microphone where the CRO indicates maximum amplitude is considered a displacement node of the air molecules.

[2]

(e) **(i)** State what is meant by the term *coherence* of two waves.

[1]

(ii) Explain how the coherence condition for interference is obtained when a plane wave front meets a pair of narrow slits which are parallel to the wave front.

....

....

.... [1]

(f) Light of wavelength 5.24×10^{-7} m is shone on a double slit whose separation is 0.220 mm. Calculate the separation of the fringes on a screen placed 0.945 m from the double slit. The screen and double slit are both placed at right-angles to the beam of light.

separation = ... m [2]

(g) **(i)** A loudspeaker emits sound at one end of an open pipe of length L. The frequency of sound from the loudspeaker is slowly increased from 20 Hz. A relatively loud sound is first heard when the frequency is f_o.

With the other end of the pipe closed, the procedure is repeated. A relatively loud sound is first heard when the frequency is f.

Determine the frequency f, in terms of f_o .

frequency = ... f_o [3]

(ii) A string in a guitar has the same length as the open pipe in **(g)(i)**. When the string is set to vibrate transversely at fundamental mode, the guitar produces a sound of frequency $\frac{f_o}{4}$.

Given that the speed of sound in air is 330 m s^{-1}, determine the speed of transverse wave in the guitar string.

speed = ______________ m s^{-1} [3]

End of Paper